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(54) **MRI SAFETY DEVICE MEANS**

MITTEL FÜR EINE MRT-SICHERHEITSVORRICHTUNG

MOYEN DE DISPOSITIF DE SÉCURITÉ D'IMAGERIE À RÉSONANCE MAGNÉTIQUE (IRM)

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Description

FIELD OF THE INVENTION

[0001] The present invention pertains to safety during imaging procedures related to magnetic fields and more particularly to protection of personnel and equipment involved in MRI diagnosis.

BACKGROUND OF THE INVENTION

[0002] In general, the static magnetic fields in MRI systems may be more than about 0.5T; some such systems have static magnetic fields greater than 3T. These magnetic fields will attract metal objects in the vicinity of the static magnets. If the object is in the vicinity of the MRI's opening, such as an opening to allow entrance of a subject to be analyzed, the object can become very difficult to remove from the interior of the MRI. Worse, in an MRI located within the hospital, for imaging patients, such a magnetic fringing field can be physically dangerous to the patient, if not fatal.

[0003] Fringe fields from a high field strength can extend to a distance determined roughly by the equation $X = \alpha B_0$, where α is a constant dependent on the magnet bore size and magnet configuration. An unshielded 1.5T magnet has a 1mT fringe field at a distance of ~9.3m, a 0.5mT field at 11.5m, and a 0.3mT field at 14.1m from the center of the magnet. To reduce the extent of the magnetic fringe field, passive (such as thick metal walls close to the magnet) and active (electromagnet systems placed in the magnet housing) superconductive magnets US Patent number 5,883,558, US Patent number 5,565,831 magnetic shielding are applied. The distance of a shielded fringe field surrounding the MRI device "MRD" opening can be reduced to about 2 meters or less.

[0004] Despite the achievable reduction of the magnetic fringe field boundaries, the existence of such field provides room for the above mentioned dangers in the MRD vicinity. Therefore, there is a long-felt need to provide an automatic and safe means of preventing loose metal objects from entering the fringe field and the MRD bore and protecting the patients from metallic instruments. US patent application 2008/0122441 discloses an MRI system in combination with a magnetic attraction prevention system.

SUMMARY OF THE INVENTION

[0005] The present invention provides magnetic resonance device "MRD", comprising an open bore and an aperture and having a fringing magnetic field outside said aperture which decreases with increasing distance from said aperture, characterized by further comprising a magnetic shielding for avoiding penetration of metal objects attracted by said fringing magnetic field through said aperture, towards said open bore; said magnetic shielding being located outside said open bore; wherein said mag-

netic shielding comprises at least one magnet; and wherein the magnetic strength of said magnetic shielding is much higher than the strength of said fringing magnetic field at any distance outside the aperture (102) of said MRD, such that said metallic objects would be pulled toward said magnetic shielding rather than be attracted into the open bore of the MRD.

[0006] The magnetic shielding may be configured as a rim, at least partially encircling the open bore.

[0007] The magnetic shielding may comprise an array of a plurality of magnets disposed along at least a part of the circumference of the rim.

[0008] The magnetic shielding may be in connection with a horizontal patient bed or a gantry (together defined as 'gantry') configured to reversibly reciprocally maneuver into and out of the open bore, along the main longitudinal axis of the same, wherein the magnetic shielding is adapted to one of (i) encircle at least a portion of the gantry, (ii) be located in connection to the gantry, (iii) be comprised within or on top of at least a portion of the gantry and a combination thereof.

[0009] The magnetic shielding may comprise a plurality of magnets.

[0010] The plurality of magnets may be provided in an array.

[0011] The magnetic shielding may be in connection with an alarming mechanism and provided in connection to a gate alarming when a metallic instrument penetrates via the gate.

[0012] The magnetic shielding may be in connection with an MRD-guard mechanism (GM) being any of (i) MRD's aperture-blocking mechanism, (ii) magnetic field shutter, (iii) one or more magnetic shielding mechanisms "MSMs", and a combination thereof, wherein the alarming mechanism is in communication with the GM when a metallic instrument penetrates via the gate.

[0013] The magnetic shielding may be in communication with a metal detector.

[0014] The magnetic shielding may be portable.

BRIEF DESCRIPTION OF THE FIGURES

[0015] In order to better understand the invention and its implementation in practice, a plurality of embodiments will now be described, by way of nonlimiting example only, with reference to the accompanying drawings, wherein

[0016] Fig. 1, illustrates (see upper figure) a schematic cross section (side view) of an MRI device (110) having an open bore with a volume of interest "VOI" (103), where maximal magnetic field is applied and an MSM (200) adjacent to the aperture of the bore; lower curve shows the strength of the magnetic field as a function of the distance between the center of the VOI (103, where maximal magnetic field is applied, 104) and a theoretical line provided throughout bore's opening (102, where a much less infringing magnetic field, namely, the magnetic field outside the magnet itself, is applied, 105), and the outer environ-

ment surrounding the MRD (106, where zero magnetic field is applied, 107);

[0017] Fig. 2a to 2f, illustrate schematic front views of a few MSMs according to several embodiments of the invention;

[0018] Fig. 3 and 4 illustrate schematic perspective views of other embodiments of the invention; MRD (110) in connection with a gantry (300) where patients (1) are placed before their imaging within the MRD; an MSM (200) is in connection with the gantry;

[0019] Fig. 5 illustrates gate (400) to an MRD (110) and/or MRD's cabinet, the gate is in connection with an MSM (200); and

[0020] Fig. 6 illustrates MRD (101) which is in connection with a portable or otherwise moveable MSM, which can be configured in more than one predefined location.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The following description is provided, alongside all chapters of the present invention, so as to enable any person skilled in the art to make use of the invention and sets forth the best modes contemplated by the inventor of carrying out this invention. Various modifications, however, will remain apparent to those skilled in the art, since the generic principles of the present invention have been defined specifically to provide a means and method for avoiding penetration of metallic objects through an aperture, towards the open bore of an MRI device.

[0022] The term "metallic objects" refers hereinafter to any metal that produces a magnetic field in response to an applied magnetic field such as ferromagnetic and ferromagnetic metals.

[0023] Reference is made now to Fig. 1, illustrating (see upper figure) a schematic cross section (side view) of an MRI device (110) having an open bore with a volume of interest (103) where maximal magnetic field is applied. The bore has an aperture (102), via which the patient is examined. Fig. 1, further illustrates (see lower curve) the strength of the magnetic field as a function of the distance between the center of the VOI (103, where maximal magnetic field is applied, 104) and a theoretical line provided throughout bore's opening (102, where a much less infinging magnetic field, namely, the magnetic field outside the magnet itself, is applied, 105), and the outer environment surrounding the MRD (106, where zero magnetic field is applied, 107). Fig. 1 further illustrates, according to one embodiment of the invention, a ring-shaped magnetic shielding member (MSM, 200) located in at the outside portion of the MRD, adjacent to the rim of the bore's opening (102). The magnetic strength of MSM (101, see lower curve) is effectively higher than the fringing magnetic fields (ibid., 105) of the MRD. Metallic instruments accidentally provided adjacent the opening 102 will thus magnetically be pulled in a safe manner towards MSM 200 rather than magnetically attracted to penetrate aperture 102 towards the MRD's magnet located within the

open bore.

[0024] Reference is still made to Fig. 1, showing an example of the invention: The magnetic shielding mechanism (MSM, 200) is especially adapted for avoiding dangerous penetration of metallic objects such as surgical tools, medical devices and sharp instruments through an aperture (102), towards the open bore of an MRI device (MRD, 110), where (103) the magnetic field (B, 104) is maximized. The MRD comprises fringing magnetic field ($B_{F/L}$, 105) which decreases with increasing distance (L, x-axis of the curve) from aperture (102). MSM (200) comprises at least one magnet with a magnetic field B_{MSM} (101). The MSM is affixed at a distance L_{MSM} from said MRD's VOI, outside the MED; here for example, the distance between the aperture and the MSM is approximately zero; wherein at any distance L, $B_{MSM} \gg B_{F/L}$.

[0025] Reference is made now to Fig. 2a to 2f, illustrating schematic front views of some of the embodiments of the invention. Fig. 2a presents one configuration of MSM (200) comprising as an example an upper magnet 201 and/or a lower magnet 202. Fig. 2b presents another configuration of MSM (200) comprising a plurality of magnets (201, 202 etc). Fig. 2b presents another configuration of MSM (200), comprising one or more continuous shaped magnets (201). Fig. 2b presents another configuration of MSM (200), namely a gate-like MSM comprising one or more magnets (201, 202) located outside the bore's aperture (102). Fig. 2e and Fig. 2f present, still in a non limiting manner, other configurations of MSM (200), here, a ring-like MSM is provided above or at least partially around an MRD's gantry, horizontal patient bed and the like (300).

[0026] Reference is made now to Fig. 3, illustrating a schematic perspective view of another embodiment of the invention. MRD (110) in connection with a gantry (300) where patients (1) are placed before their imaging within the MRD. According to this embodiment of the invention, an MSM (200), is in connection with said gantry, e.g., positioned opposite to the MRD's aperture (102). The magnetic strength of the MSM is effectively stronger (101) than the fringing magnetic field at its location (107) and significantly weaker than the magnetic field applied in the VOI (104). Moreover, the magnetic field curve of the MSM (101) is very sharp. Top view of the magnetic gantry (300) is given at view 300A.

[0027] Reference is made now to Fig. 4, illustrating a schematic perspective view of another embodiment of the invention. An MRD (110) in connection with a gantry (300) of another type. According to this embodiment of the invention, as described above, MSM (200) is in connection with said gantry, e.g., positioned in opposite to the MRD's aperture (102). As shown separately in a top schematic view, gantry 300D comprises a magnetic rim (300B) at the circumference of a non-magnetic portion of the gantry

[0028] (300C). The magnetic strength of the MSM is effectively stronger (101) than the fringing magnetic field at its location (105-107) and significantly weaker than the

magnetic field applied in the VOI (104). The magnetic field curve of the MSM (101) has a broad shape.

[0029] Reference is made now to Fig. 5, illustrating a schematic perspective view of another embodiment of the invention. A gate (400) to an MRD (110) and/or MRD's cabinet is in connection with an MSM (200). Patient to be imaged is guided to pass said MSM before approaching the MRD's adjacent environment. The magnetic field (101) within gate (400) is significantly greater than the magnetic fringing field (107) at that location.

[0030] Reference is made now to Fig. 6, illustrating a schematic perspective view of another embodiment of the invention. MRD (101) is in connection with a portable or otherwise moveable MSM, which can be configured in more than one predefined location. In one example of the invention, MSM is situated close to MED's bore opening (e.g., at the bore's aperture or in adjacent to the aperture) at location 200A, along the MRD's gantry (300) at location 200b or at respectively remote location 200c, near gantry's end. In one embodiment of the invention, MSM is reversibly reciprocated by means of telescopic mechanical mechanism, by one or more levers or transformation means or in any other useful mechanism.

Claims

1. A magnetic resonance device "MRD" (110), comprising an open bore (103) and an aperture (102) and having a fringing magnetic field ($B_{F/L}$) outside said aperture which decreases with increasing distance (L) from said aperture (102), **characterized by** further comprising a magnetic shielding (200) for avoiding penetration of metal objects attracted by said fringing magnetic field through said aperture (102) towards said open bore (103); said magnetic shielding (200) being located outside said open bore (103); wherein said magnetic shielding (200) comprises at least one magnet; and wherein the magnetic strength (B_{MSM} , 101) of said magnetic shielding is much higher than the strength of said fringing magnetic field ($B_{F/L}$) at any distance L outside the aperture (102) of said MRD, such that said metallic objects would be pulled toward said magnetic shielding (200) rather than be attracted into the open bore (103) of the MRD (110).
2. The MRD of claim 1, wherein said magnetic shielding (200) is configured as a rim, at least partially encircling said open bore (103).
3. The MRD of claim 2, wherein said magnetic shielding (200) comprises an array of a plurality of magnets disposed along at least a part of the circumference of said rim.
4. The MRD of claim 1, additionally comprising a gantry configured to reversibly reciprocally maneuver into

and out of said open bore (103), along the main longitudinal axis of the same and wherein said magnetic shielding (200) encircles at least a portion of said gantry and/or is connected to said gantry.

5. The MRD of claim 4, wherein said magnetic shielding (200) comprises a plurality of magnets.
6. The MRD of claim 1 comprising a portable or otherwise moveable magnetic shielding mechanism "MSM" comprising said magnetic shielding (200) which can be configured in more than one predefined location.
7. The MRD of claim 1 additionally comprising a gantry, wherein said magnetic shielding is reversibly reciprocally moveable along said gantry between two or more predefined locations by means of a telescopic mechanical mechanism.
8. The MRD of claim 1, further comprising a gate (400) through which a patient to be image is guided to pass, wherein said magnetic shielding is connected to said gate.
9. The MRD of claim 8, wherein said gate comprises a gate alarming mechanism and wherein said MRD further comprises an MRD-guard mechanism "GM" in communication with said gate alarming mechanism when a metallic instrument penetrates via said gate, said GM being an MRD's aperture blocking mechanism, a magnetic field shutter or a combination thereof.
10. The MRD of claim 1, wherein said magnetic shielding (200) is in communication with a metal detector.

Patentansprüche

1. Eine Magnetresonanzvorrichtung "MRD" (110), die eine offene Bohrung (103) und eine Öffnung (102) aufweist und ein Magnetstrefeld ($B_{F/L}$) außerhalb der besagten Öffnung hat, das mit zunehmendem Abstand (L) von besagter Öffnung (102) schwächer wird, **gekennzeichnet dadurch, dass** es darüber hinaus eine magnetische Abschirmung (200) aufweist, um zu verhindern, dass metallene Gegenstände eindringen, die von besagtem Magnetstrefeld durch die Öffnung (102) zur offenen Bohrung (103) gezogen werden; diese magnetische Abschirmung (200) befindet sich außerhalb der offenen Bohrung (103); wobei die magnetische Abschirmung (200) mindestens einen Magneten aufweist; und wobei die Magnetfeldstärke (B_{MSM} , 101) dieser magnetischen Abschirmung viel höher ist als die Stärke des besagten Magnetstrefeldes ($B_{F/L}$) in einem Abstand L außerhalb der Öffnung (102) der besagten MRD, so

dass die metallenen Gegenstände zu der magnetischen Abschirmung (200) und nicht in die offene Bohrung (103) der MRD (110) gezogen werden.

2. Die MRD gemäß Anspruch 1, wobei die magnetische Abschirmung (200) als Kranz konfiguriert ist, der mindestens teilweise die offene Bohrung (103) umgibt.
3. Die MRD gemäß Anspruch 2, wobei die magnetische Abschirmung (200) eine Anordnung einer Vielzahl von Magneten aufweist, die entlang mindestens eines Teils des Umfangs dieses Kranzes angeordnet sind.
4. Die MRD gemäß Anspruch 1, die zusätzlich einen Gantry aufweist, der so konfiguriert ist, dass er sich umschaltbar wechselseitig in die und aus der offenen Bohrung (103) entlang ihrer Hauptlängsachse bewegen kann und wobei die magnetische Abschirmung (200) mindestens einen Teil des Gantry umgibt und/oder mit diesem Gantry verbunden ist.
5. Die MRD gemäß Anspruch 4, wobei die magnetische Abschirmung (200) eine Vielzahl von Magneten aufweist.
6. Die MRD gemäß Anspruch 1, die einen tragbaren oder auf andere Weise beweglichen magnetischen Abschirmungsmechanismus "MSM" aufweist, der die magnetische Abschirmung (200) enthält, die an mehr als einer vordefinierten Stelle konfiguriert werden kann.
7. Die MRD gemäß Anspruch 1, die zusätzlich einen Gantry aufweist, wobei die magnetische Abschirmung umschaltbar wechselseitig entlang des besagten Gantry zwischen zwei oder mehr vordefinierten Stellen über einen mechanischen Teleskopmechanismus beweglich ist.
8. Die MRD gemäß Anspruch 1, die darüberhinaus ein Tor (400) aufweist, durch das ein Patient hindurchgeführt wird, um abgeleitet zu werden, wobei die magnetische Abschirmung mit diesem Tor verbunden ist.
9. Die MRD gemäß Anspruch 8, wobei das Tor einen Alarmmechanismus aufweist und wobei die MRD darüberhinaus einen MRD-Schutzmechanismus "GM" in Verbindung mit dem Tor-Alarmmechanismus aufweist, für den Fall, dass ein metallener Gegenstand durch dieses Tor eindringt, der besagte GM kann dabei ein Blockiermechanismus der MRD-Öffnung, ein Magnetfeldverschluss oder eine Kombination daraus sein.
10. Die MRD gemäß Anspruch 1, wobei die besagte ma-

gnetische Abschirmung (200) in Verbindung mit einem Metalldetektor steht.

5 Revendications

1. Un dispositif à résonance magnétique "MRD" (110), comprenant un orifice ouvert (103) et une ouverture (102) et possédant un champ magnétique à franges ($B_{F/L}$) en dehors de ladite ouverture qui diminue avec une distance croissante (L) à partir de ladite ouverture (102), **caractérisé en ce qu'il** comprend en outre un blindage magnétique (200) destiné à éviter la pénétration d'objets métalliques attirés par ledit champ magnétique à franges au travers de ladite ouverture (102) vers ledit orifice ouvert (103), ledit blindage magnétique (200) étant situé à l'extérieur dudit orifice ouvert (103), où ledit blindage magnétique (200) comprend au moins un aimant, et où la résistance magnétique (B_{MSM} , 101) dudit blindage magnétique est nettement supérieure à la résistance dudit champ magnétique à franges ($B_{F/L}$) à une distance L quelconque à l'extérieur de l'ouverture (102) dudit MRD, de sorte que lesdits objets métalliques soient tirés vers ledit blindage magnétique (200) plutôt que d'être attirés dans l'orifice ouvert (103) du MRD (110).
2. Le MRD selon la Revendication 1, où ledit blindage magnétique (200) est configuré sous la forme d'une jante, encerclant au moins partiellement ledit orifice ouvert (103).
3. Le MRD selon la Revendication 2, où ledit blindage magnétique (200) comprend une matrice d'une pluralité d'aimants disposés le long d'au moins une partie de la circonférence de ladite jante.
4. Le MRD selon la Revendication 1, comprenant en outre un portique configuré de façon à manoeuvrer en va-et-vient et de manière réversible dans et hors dudit orifice ouvert (103), le long de l'axe longitudinal principal de celui-ci et où ledit blindage magnétique (200) encercle au moins une partie dudit portique et/ou est raccordé audit portique.
5. Le MRD selon la Revendication 4, où ledit blindage magnétique (200) comprend une pluralité d'aimants.
6. Le MRD selon la Revendication 1 comprenant un mécanisme de blindage magnétique "MSM" portatif ou autrement déplaçable comprenant ledit blindage magnétique (200) qui peut être configuré dans plusieurs emplacements prédéfinis.
7. Le MRD selon la Revendication 1 comprenant en outre un portique, où ledit blindage magnétique est déplaçable en va-et-vient et de manière réversible

le long dudit portique entre deux ou plus emplacements prédéfinis au moyen d'un mécanisme mécanique télescopique.

8. Le MRD selon la Revendication 1, comprenant en outre un portillon (400) au travers duquel un patient à imager est guidé de façon à passer, où ledit blindage magnétique est raccordé audit portillon. 5
9. Le MRD selon la Revendication 8, où ledit portillon comprend un mécanisme d'alarme de portillon et où ledit MRD comprend en outre un mécanisme de protection de MRD "GM" en communication avec ledit mécanisme d'alarme de portillon lorsqu'un instrument métallique pénètre par l'intermédiaire dudit portillon, ledit GM étant un mécanisme de blocage d'ouverture du MRD, un obturateur de champ magnétique, ou une combinaison de ceux-ci. 10 15
10. Le MRD selon la Revendication 1, où ledit blindage magnétique (200) est en communication avec un détecteur de métaux. 20

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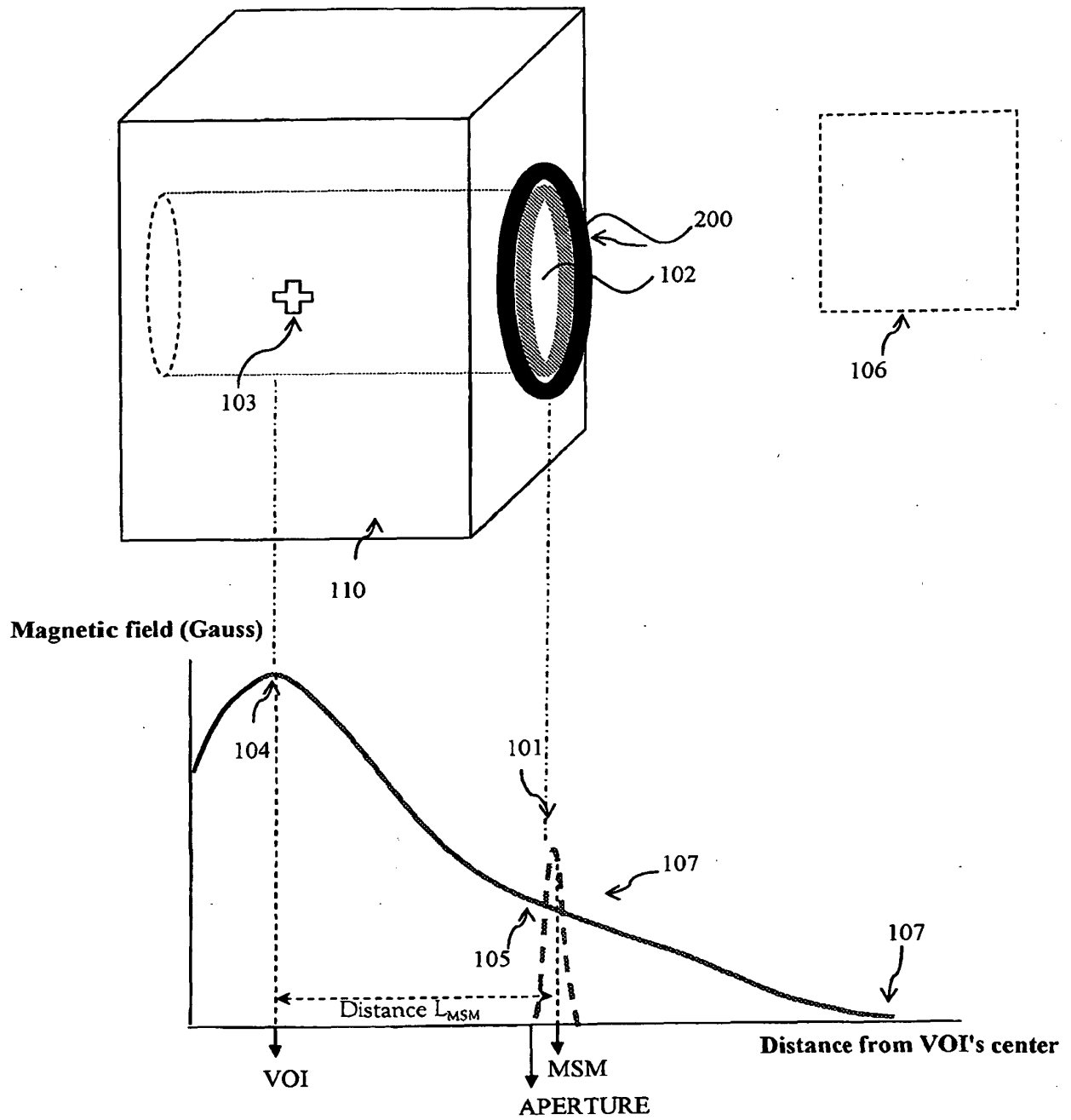
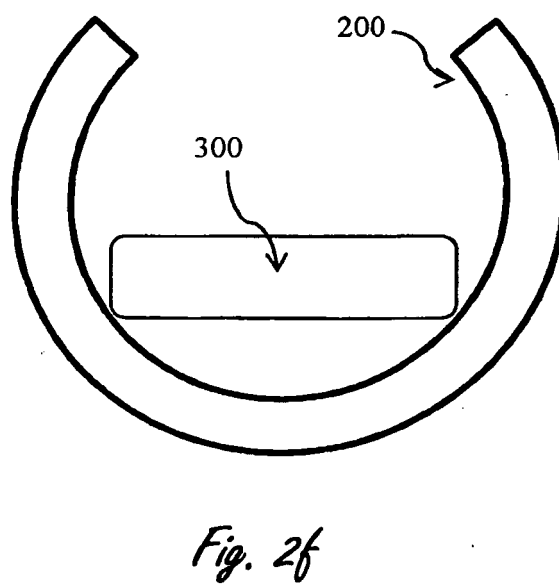
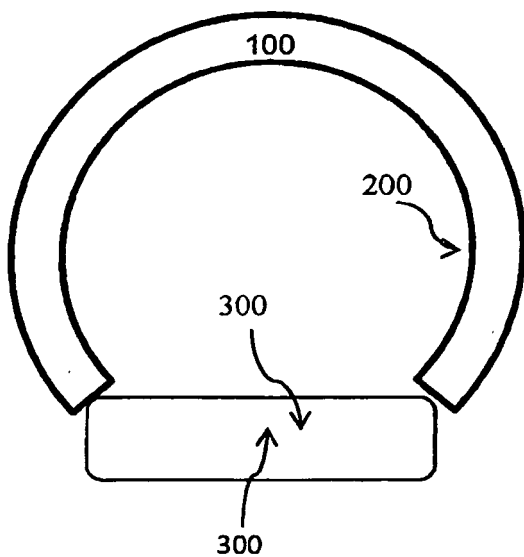
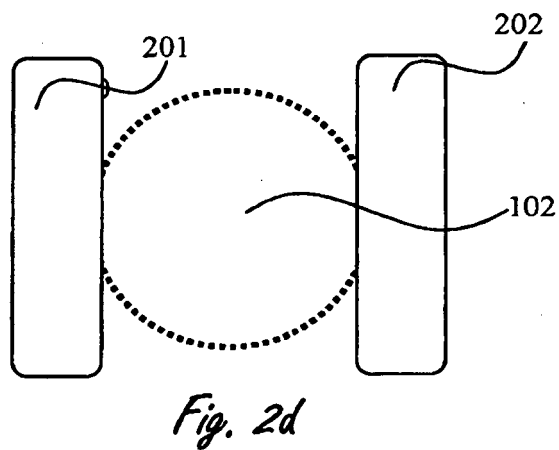
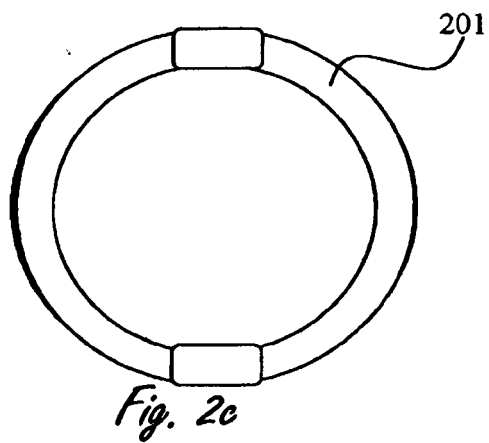
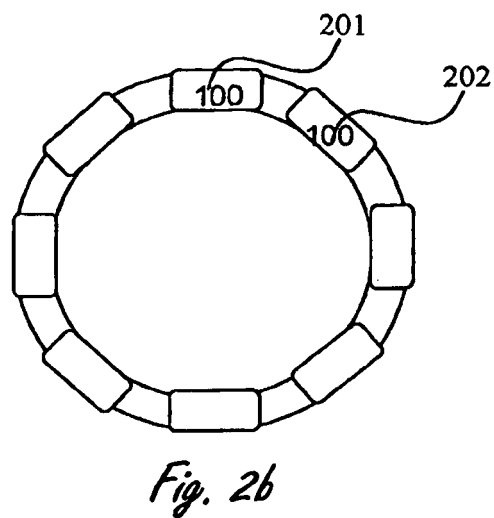
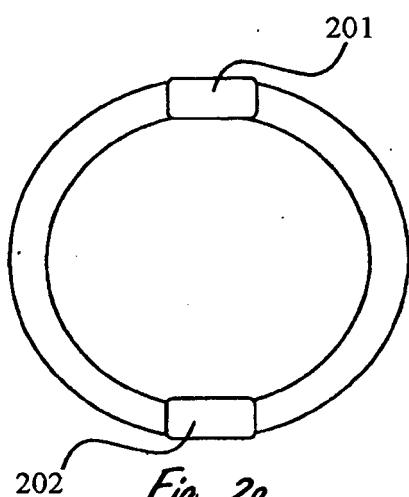


Fig. 1



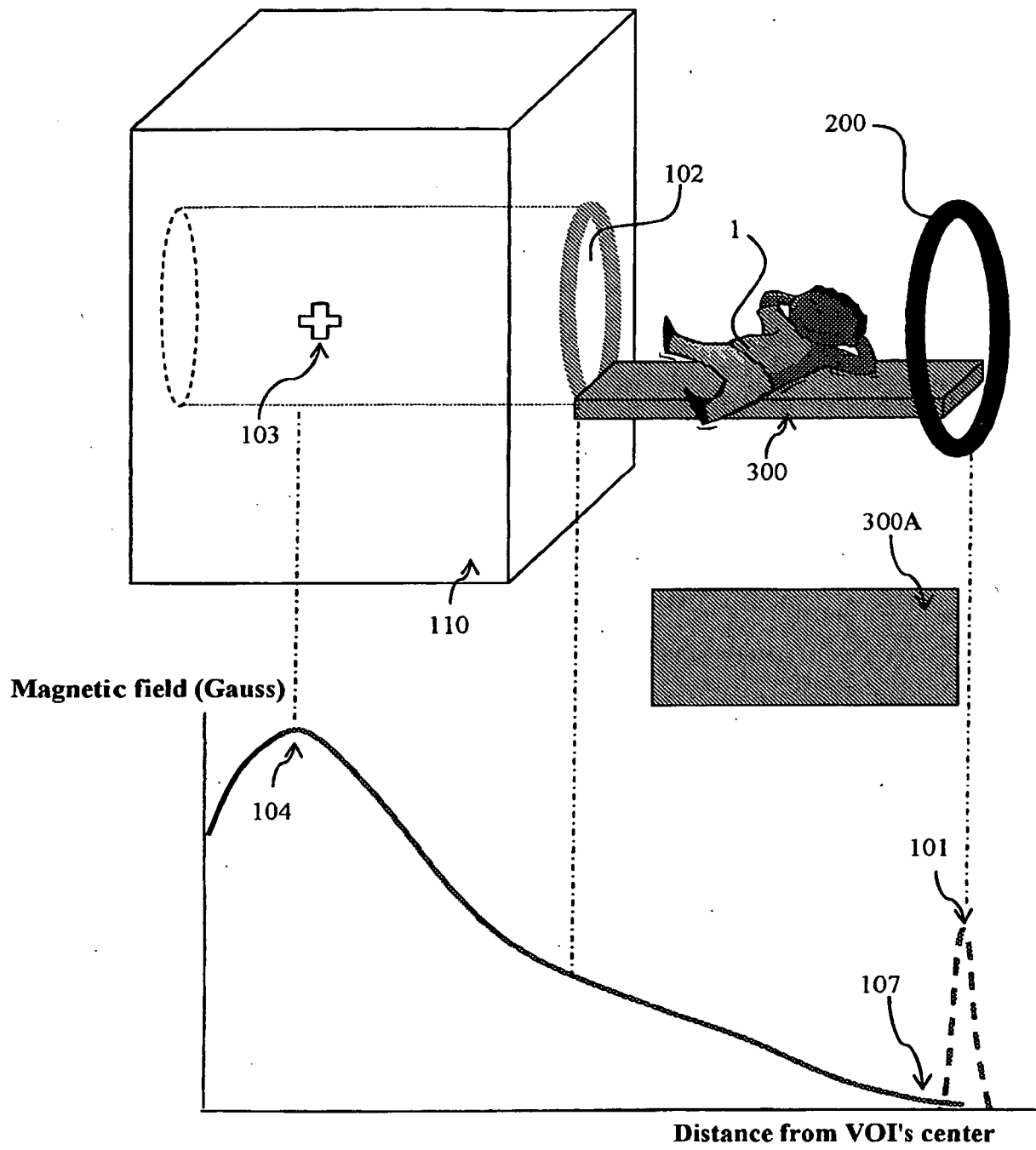


Fig. 3

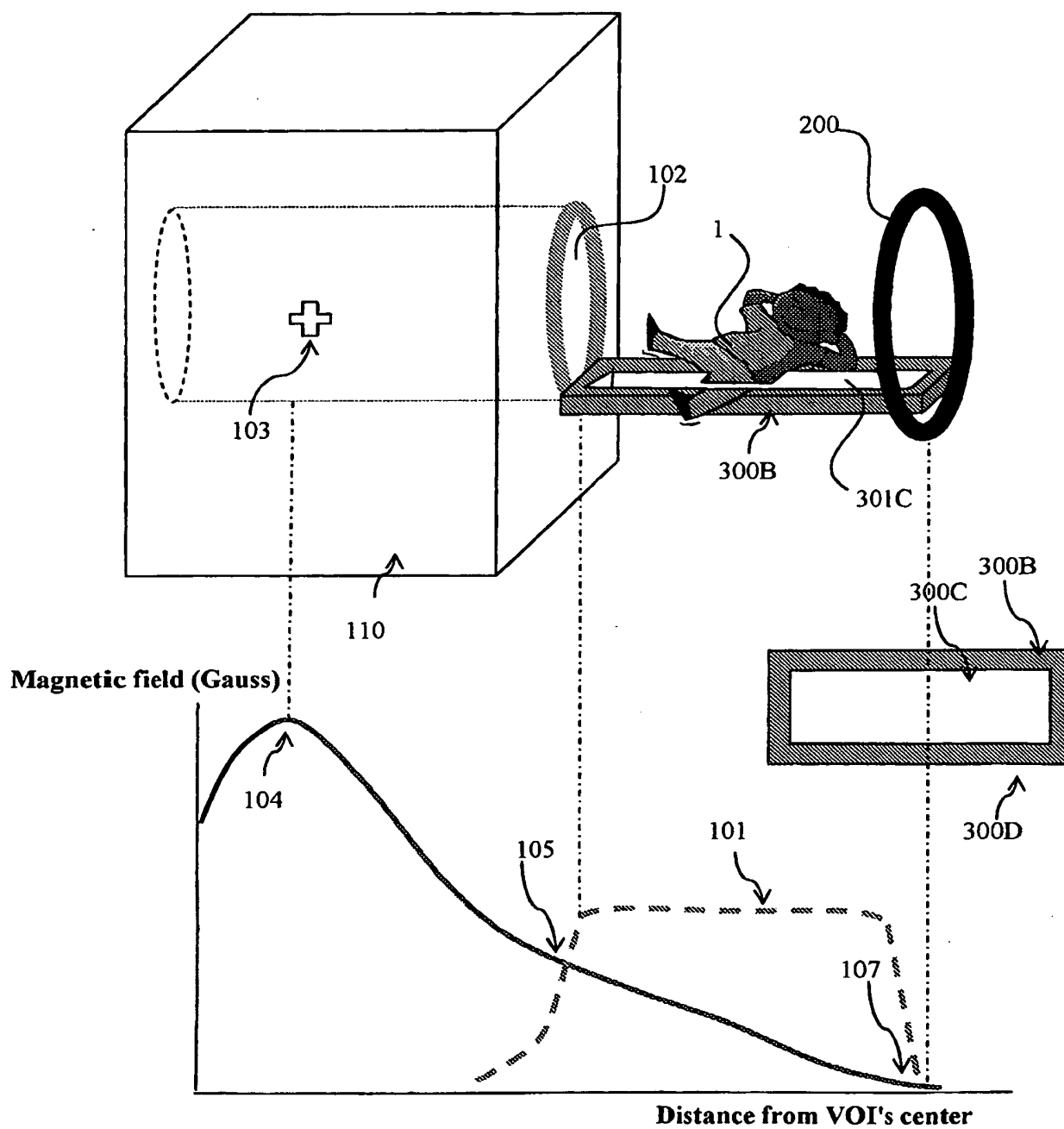


Fig. 4

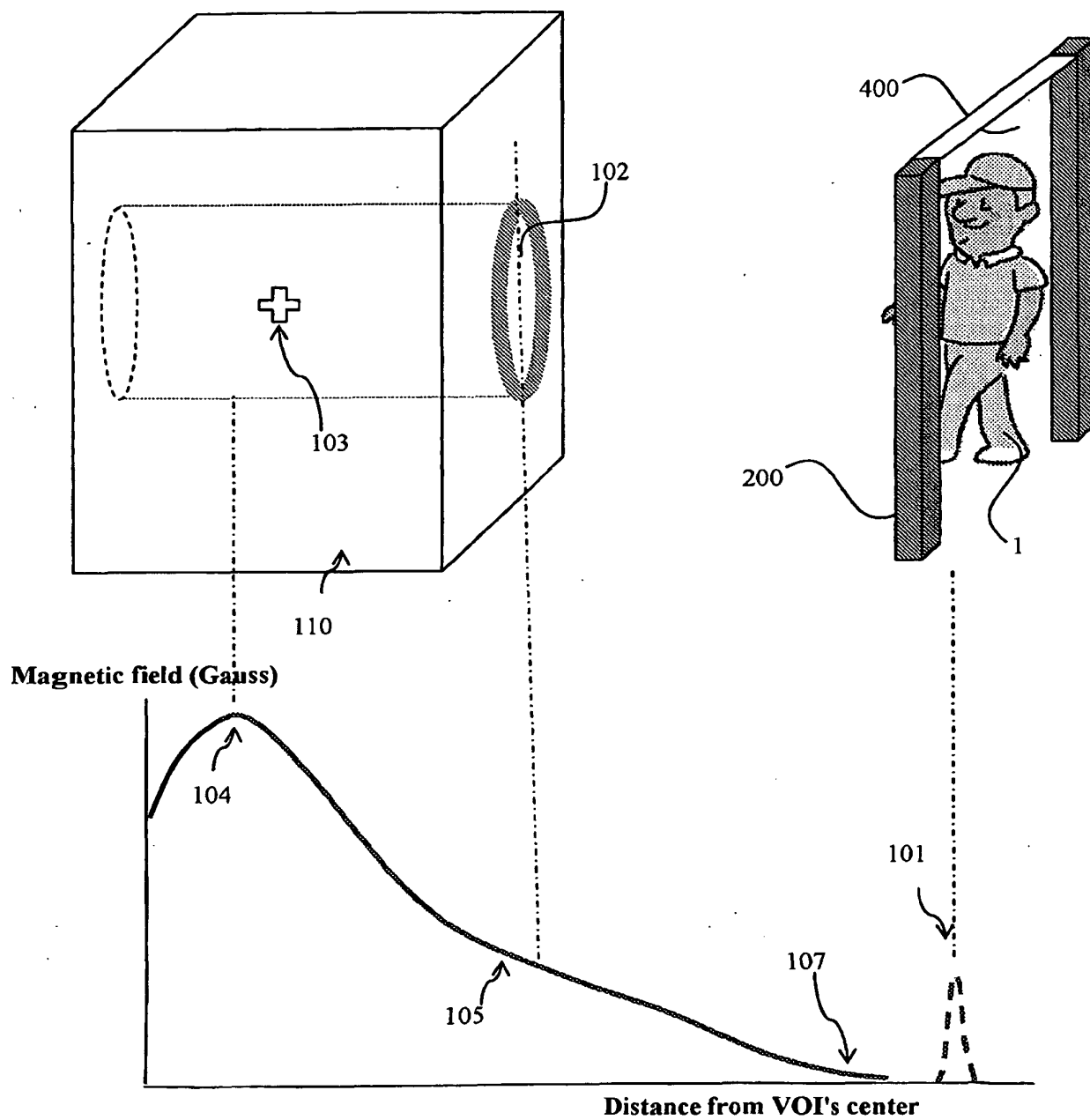


Fig. 5

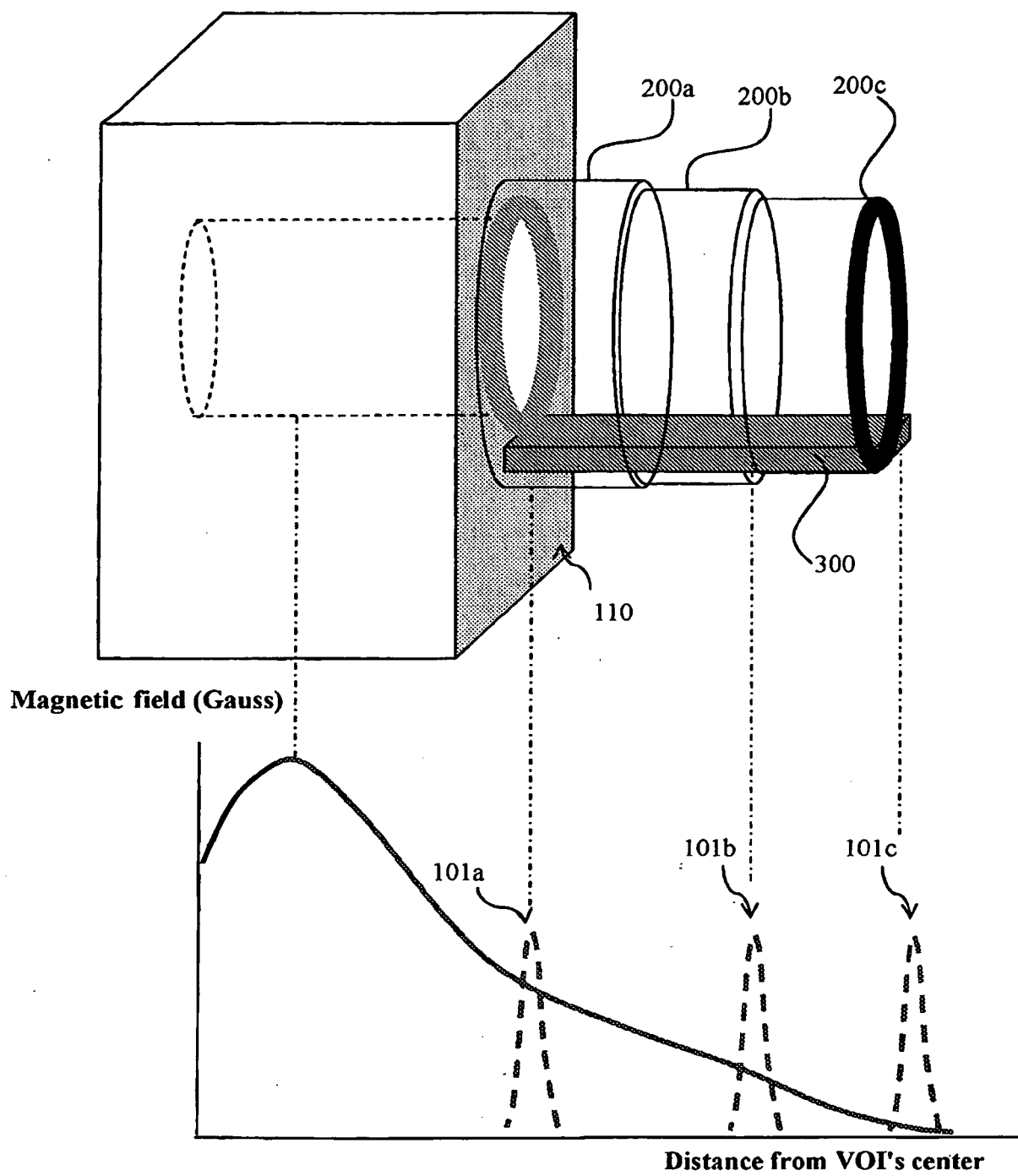


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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